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EFFECT OF A HEATED PLATINUM WIRE ON A SEALED CO_2 LASER SYSTEM

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FOREWORD

This report was prepared by F. M. Taylor and A. Lombardo, Systems Research Laboratories, Inc., 500 Woods Drive, Dayton, Ohio, 45432, in conjunction with W. C. Eppers of the Air Force Avionics Laboratory, Wright-Patterson Air Force Base, Ohio, under Project No. 5237, Task No. 5237-10. The Systems Research Laboratories effort was performed under Contract F33615-67-C-1138 for the Air Force Avionics Laboratory, Wright-Patterson Air Force Base, under the technical cognizance of D. R. Nordstrom.

This report was submitted by the authors February 1968.

This technical report has been reviewed and is approved.

RAYMOND J. NORDLUND
Chief Scientist
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ABSTRACT

A heated platinum wire was used in a sealed CO_2-N_2-He laser system, resulting in increases in output power that were dependent on the initial fill pressure of CO_2. The system was also filled with a CO_2-He mixture and made to lase. Heating of the platinum wire caused a decrease in output power. It was tentatively concluded that the platinum catalyzes the reaction $CO + O \rightarrow CO_2$, permitting a higher concentration of CO_2 in a sealed system than is otherwise possible.

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SECTION I
INTRODUCTION

There has recently been some speculation (References 2 and 3) concerning the effect of decomposition of CO_2 in the plasma discharge of a sealed CO_2 laser. Such decomposition may result in the generation of new species of gases existing in some dynamic equilibrium population balance. In particular, CO, O, or O_2 are likely to result. The final specie concentration obtained in a sealed system could be dependent on numerous factors which often are only of incidental or minor importance in a flowing CO_2 system. Among these may be: electrode material, the type and quantity of impurities present in the original gases; or impurities resident in the system due to either a partial, or perhaps a total, lack of vacuum clean-out. Such impurities, in addition to the electrode material, may participate in the various chemical reactions promoted by the plasma either directly or catalytically. For instance, the free oxygen (O or O_2) may be precipitated out of the gaseous mixture in solid oxides, thus preventing reoxidation of C and CO. In general, the chemical activity going on will result in a steady or quasi-steady state in which the CO_2 percentage is lower than that of the initial fill.

Both Howe and Harrigan (References 2 and 3) report that CO may function as an intermediate gas in populating the upper laser level of CO_2. However, in spite of such possible benefit, it would appear that the most desirable population specie balance in a sealed system would be as close as possible to the optimal for a flowing system where such specie population balance may, to a higher degree, be arbitrarily determined by the experimenter.

SECTION II
EXPERIMENTAL METHOD AND DATA

This report describes the beneficial effects of using a heated platinum wire in a sealed CO_2 system. Figure 1 shows the experimental setup. For all of the mixtures tried where N_2 was included as one of the fill gases, heating of the platinum wire resulted in a power increase. The loop structure shown was intended to provide a circulating convection flow of the plasma products over a heated Hopcalite catalyst (60% MnO_2 and 40% CuO). This procedure failed to produce a change in output power. It is suspected that the catalyst was poisoned by water that may have been in the commercial grade N_2 used. The platinum was #30 gauge thermocouple wire and was electrically heated to an estimated 850°C. The mirrors were fully aluminized with a pinhole method used for coupling. The platinum, as may be seen from Figure 1, was located external to the plasma and was not used as part of the electrodes. This was done to isolate the action of the heated platinum, since even when using "cold" cathodes, the surface temperature of the cathode may be elevated due to ion bombardment. W. J. Witteman (References 6, 7, and 8) has used platinum as electrodes to avoid reaction with the gas components and has achieved fairly high power output (20 watts) in a sealed CO_2-N_2-H_2 system.

Figure 2 illustrates the effect of the heated platinum on initial peak power values versus the initial percentage of CO_2 by pressure in the tube. Not shown in either Figure 2 or Figure 3 is a short-term (2 to 3 seconds) variation in the output power of about 10 to 15%. By monitoring the various lines that were lasing with a Perkin-Elmer infrared monochromator, it was determined that

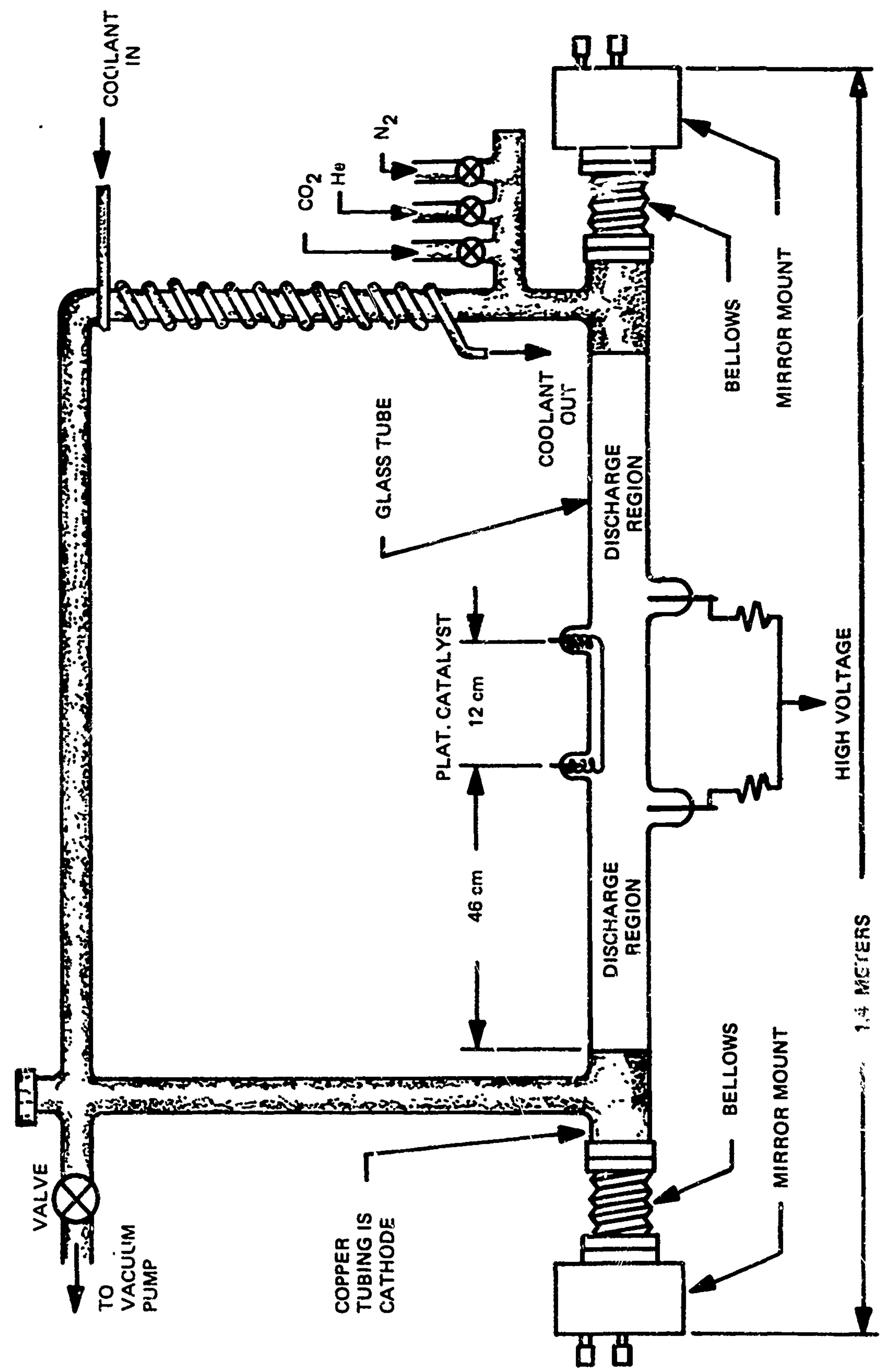

Figure 1. Experimental Setup for Catalyzed CO_2 Laser System

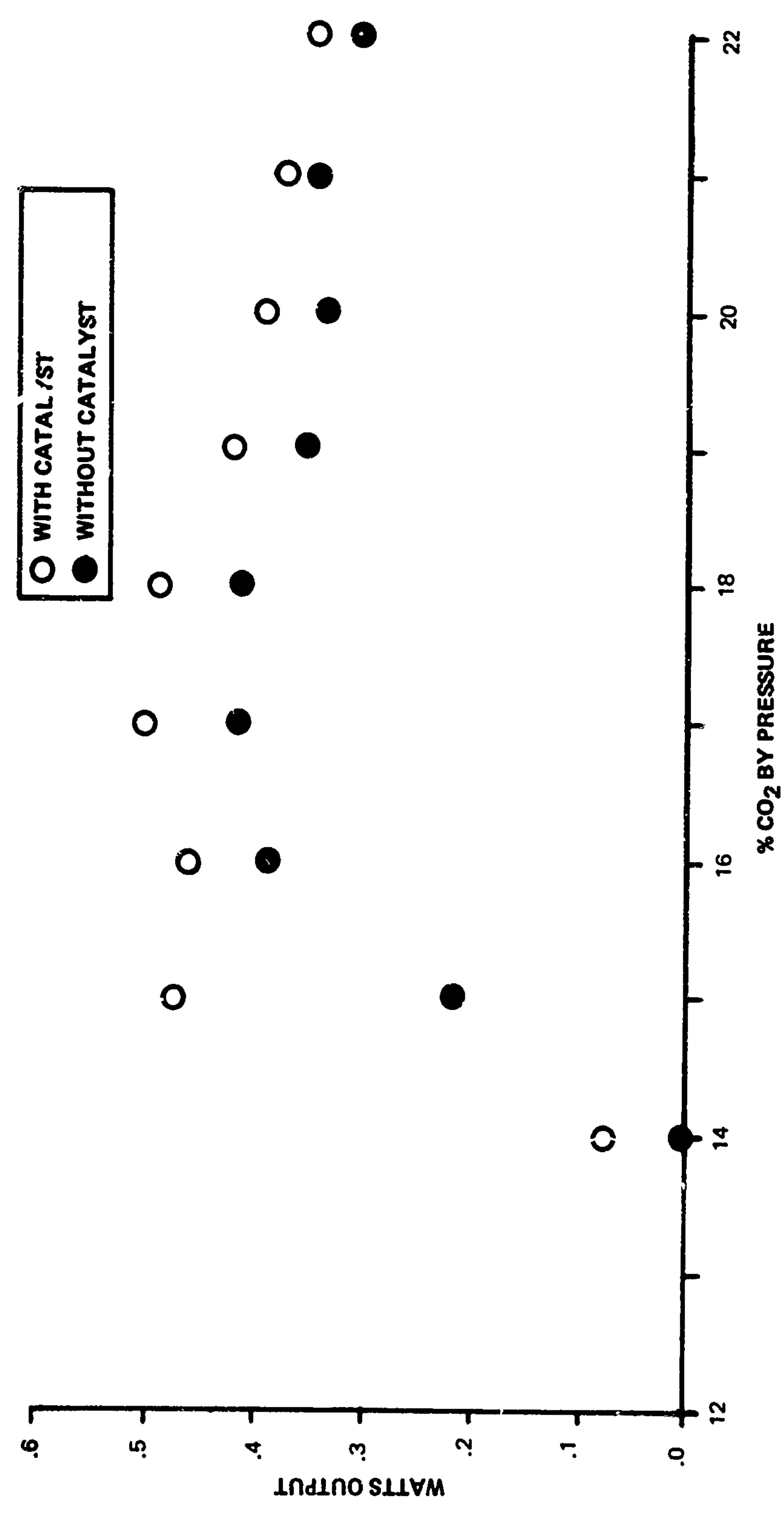

Figure 2. Output Power for Varying Initial Fill Pressures of CO_2

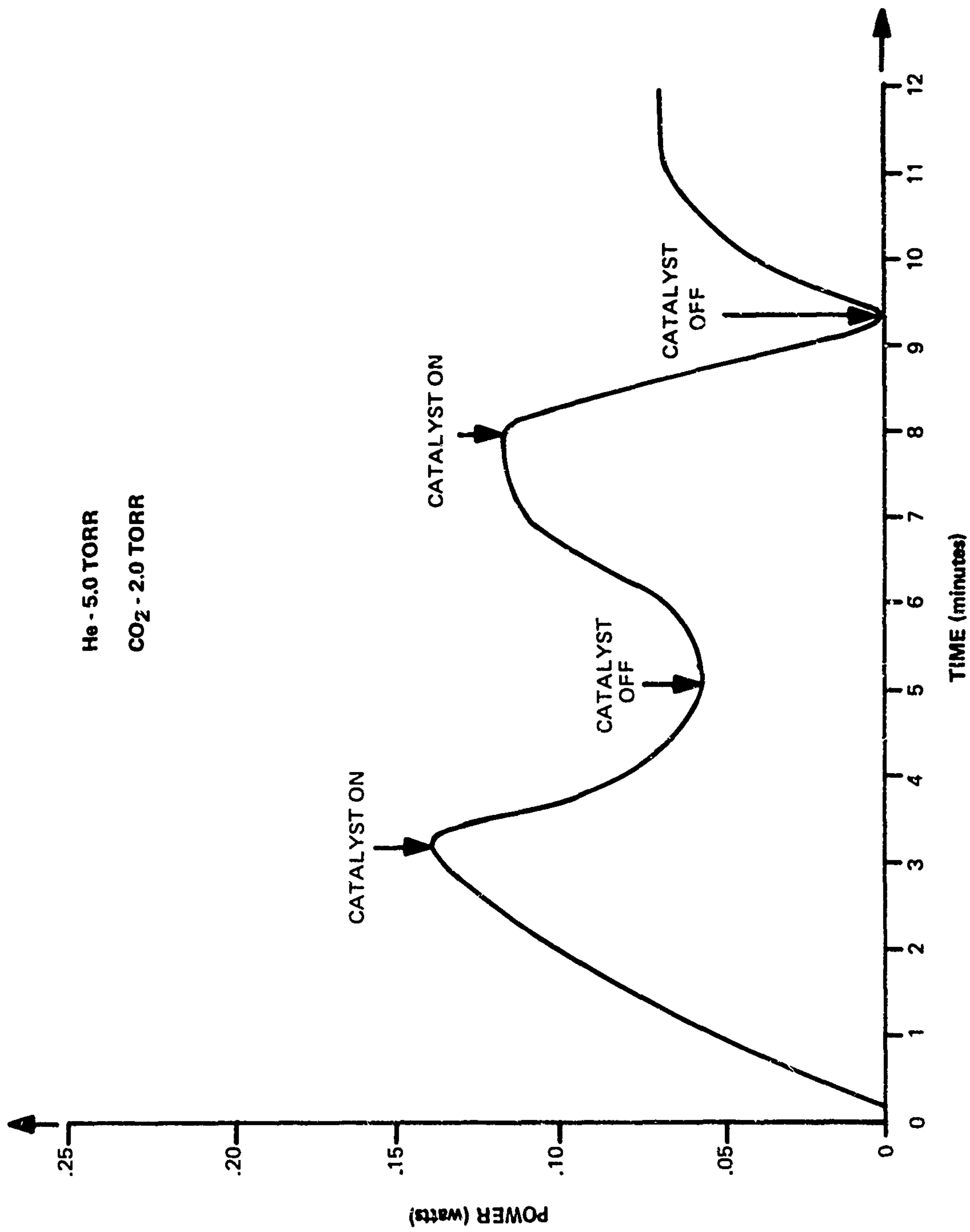

Figure 3. Output Power for He - CO_2 Fill

this variation coincided with the appearance and disappearance of various P-branch transitions around P(20). Such line drift has been attributed by Rigden and Moeller (Reference 5) to variations in cavity length. This effect appeared independent of whether the platinum wire was heated or not. The specific lines lasing were P(18), P(20), P(22), and P(24). There was no discernible temperature change (< 1°C) of the gases when the platinum was heated. The largest power increase obtained was at 15% CO_2 (1.05 torr CO_2, 1.0 torr N_2, 5.0 torr He). It had previously been determined that the optimal partial pressures for the same system under flowing conditions were approximately 1.0 torr CO_2, 1.0 torr N_2, 5.0 torr He (these pressures were uncorrected for flow error).

A mixture of He and CO_2 was admitted to the tube and made to lase. The results are shown in Figure 3. As may be seen from the curve, heating of the platinum in this case extinguished laser action. The two cases may be explained if the heated platinum is catalyzing the reaction $CO + O \rightarrow CO_2$. In the first case, with the N_2 present and performing the intermediate pump gas function of populating the upper laser level of CO_2, a power increase is obtained as the detrimental effects of the free oxygen (Reference 4) are reduced and the CO_2 percentage is brought nearer the optimal. In the second case, the CO generated by the discharge is apparently functioning as the pump gas. Note in Figure 3 that the output of the laser was zero upon initial turn-on, and remained so until sufficient CO had been generated to create a population inversion in the CO_2. Thus, activating the catalyst in this system caused a power reduction as the percentage of one of the essential ingredients (CO) in the energy scheme was reduced.

To further verify this hypcthesis, the visible Angstrom bands of CO at 484 mμ(0-1) and at 520 mμ(0-2) (Reference 3) were monitored with a monochromator, photomultiplier, and phase-lock amplifier combination. The results in Figure 4 show an evident decrease in intensity of the CO lines each time the platinum wire was heated, indicating a decrease in the CO concentration in agreement with the above hypothesis. The power supply used was unregulated and there was a slight increase in current through the tube when the platinum was heated. In Figure 4d, however, the current was manually held constant. An additional check was made by filling the system with pure CO_2 and then with pure N_2. For a CO_2 fill having the same partial pressure as for the mixed fill, monitoring of the above CO Angstrom bands showed similar intensity decreases when the platinum was heated. For the pure fill of N_2, monitoring of the visible lines of N_2 showed no change upon heating the platinum.

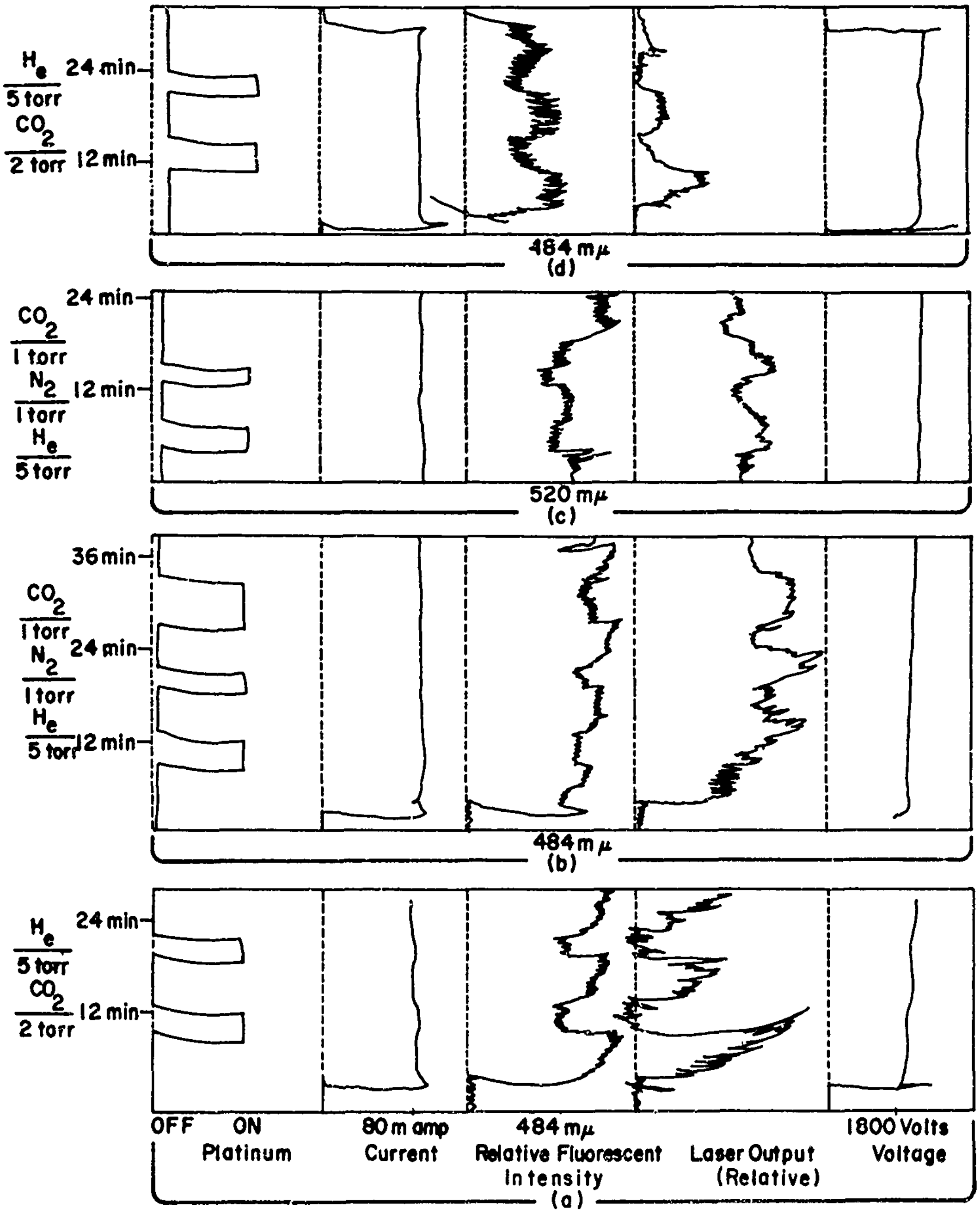

Figure 4. Effect of Catalyst

SECTION III
CONCLUSION

It thus appears that the gas compositions of sealed gas lasers with chemically active constituents may be substantially modified by the inclusion in the tube of catalysts. The catalyst and the reaction promoted may be chosen to bring the specie population balance nearer the optimal for the particular laser than might otherwise be possible in a sealed system. Such catalytic action of incidental or deliberate ingredients, such as nickel and H_2O (Reference 1) of CO_2 lasers may partially explain some of the often conflicting claims as to optimal gas percentages, flow rates, etc., that have characterized much of the CO_2 work reported in the literature.

REFERENCES

1. S. Beckman, J. Morrel, G. Egloff, 1946. Catalysis, Reinhold Publishing Co.

2. F. Harrigan, 1966. Raytheon Final Technical Report, Waltham, Mass., AD 637-023.

3. G. Herzberg, 1966. Molecular Spectra and Molecular Structure I, 2nd Ed., p. 35.

4. J. A. Howe, 1965. Appl. Phys. Letters 7, 12.

5. J. D. Rigden, G. Moeller, 1966. IEEE Journal of Quantum Electronics, Vol. QE-2, No. 9, 365.

6. W. J. Witteman, 1965. Phys. Letters 18, 125 - 127.

7. W. J. Witteman, 1966. Philips Research Repts., 21, 73 - 84.

8. W. J. Witteman, 1966. IEEE Journal of Quantum Electronics, Vol. QE-2, No. 9, 375.

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